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THE BOTANICAL GAZETTE

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CONTENTS:

Cell union in herbaceous grafting. (With plates XXX and XXXI.)—*John S. Wright.* 285
Observations on the zoospores of Draparnaldia. (With plate XXXII.)—*L. N. Johnson.* 294
New and noteworthy North American plants.—*John M. Coulter* and *Elmon M. Fisher.* 299
Some recent investigations on the evaporation of water from plants.—*Albert F. Woods.* 304
Noteworthy anatomical and physiological researches 311
The plant and its relation to iron.—*J. Christian Bay.*
Latent irritability.—*J. Christian Bay.*
Studies upon the Xyrideæ.—*Theo. Holm.*
Briefer Articles 315
Notes from Gull Lake Biological Station.—*Conway McMillan.*
Editorial 316
Current Literature 319
Open Letters 324
A suggestion.—*Theo. Holm.*
Notes and News 325

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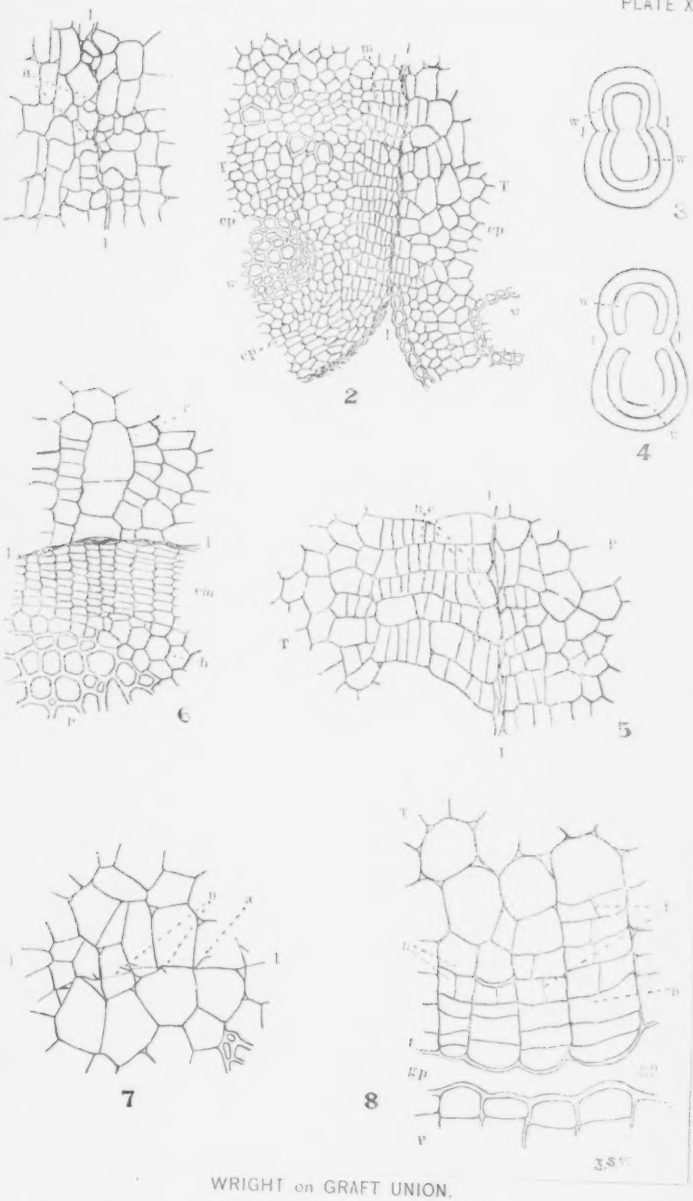

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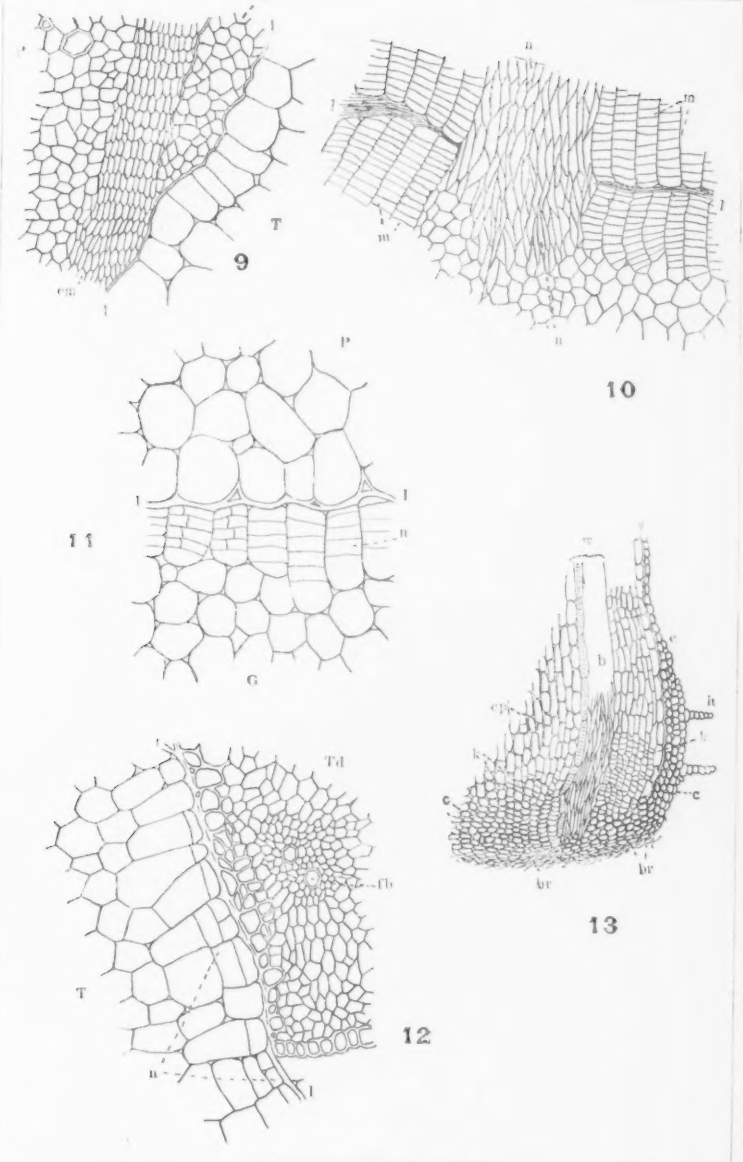


WRIGHT on GRAFT UNION.

BOTANICAL GAZETTE

AUGUST, 1893.

Cell union in herbaceous grafting.

JOHN S. WRIGHT.

WITH PLATES XXX AND XXXI.

The plants mainly employed in this study were tomatoes, potatoes and geraniums, although some work was done with cactus, tradescantia, and a few other kinds of plants. The entire work was done in the winter and early spring of 1892, the experiments being performed in the greenhouse attached to the laboratory of vegetable physiology of Purdue University.

Three methods of grafting were employed, inarching, splice grafting and cleft or wedge grafting. It is needless to describe these well known methods here farther than to say that by the inarching method the scion is allowed to remain on the parent stock until union is formed, while by the splice and wedge or cleft methods the scion must from the start sever all connection with the parent and be sustained entirely by the new stock. In plants which are very delicate and of slow or uncertain union, the inarching method is the surer, though in most cases the cleft and wedge are safe and most convenient.

In all cases the stock and scion were held in place by thin strips of raffia until union was accomplished when they were removed to allow the diameter of the stem to increase.

It is only in certain stages of growth that herbaceous plants may be easily grafted; in quite young plants the tissues are not strong enough to survive the injuries inflicted in the operation, while in older parts, those past or nearly past the growing stage, the union does not take place readily because of the scarcity of meristematic tissue, as union depends upon the active growth of this tissue. In herbaceous grafting the rule is to use only such stems as will snap in breaking and

not crush at the point of yielding. The scions used in this work were in all cases vigorous growing young tips. In young plants the stocks were cut close to the ground, in older plants higher branches served the purpose.

In the experiments it was noticed that scions which had grown in vertical position more readily united with stocks which allowed them to retain their original position. Shortly after the operation of grafting many scions wilt and remain in a drooping state several hours or even a day, but with careful attention revive permanently.

Accounts were kept of each graft and when it arrived at desired age for study the parts at the point of union were cut into small pieces suitable for sectioning, dehydrated in a Thomas apparatus and prepared for sectioning by the celloidin method.

Although all grafts were recorded so that sections might be had showing grafts at various ages and all stages of cell union, study of sections showed that in most instances all stages of cell union could be found in a single graft. Longitudinal and transverse sections were made of most grafts, but the longitudinal section seldom showed anything in addition to that shown by transverse sections. Camera lucida drawings were made of all sections of importance, and in connection with the slides used for study. A number of these drawings have been selected to illustrate this article.

Graft of tomato on tomato.—Two lateral and parallel tomato branches belonging to separate plants had tangential slices, each about three-fifths of an inch long, removed from their adjacent sides; these cut surfaces were bound firmly together with raffia so that similar tissues met. After about four weeks the graft was sectioned for study. The cross section showed the line of union marked by a ragged brownish wall, which passed with but one interruption entirely across the stem. In longitudinal section this junction of the two members was marked by rows of small irregular parenchyma cells with here and there the intervention of a thickened brown wall (fig. 1). The sections showed that the cells which had been injured in grafting had died, while those immediately beneath them were stimulated to a vigorous growth forming meristematic tissue in each member, which in its advance pushed the broken walls of the dead boundary cells into line, forming between the two members of the graft the fragmental

brown wall noted in the section (fig. 2, *l*,*l*). This brown wall in all the instances observed was unaffected by stains used on the section. As will be seen farther on, this wall tends to disappear with age until at last only a mere trace of its existence is left.

In this case the tangential slices, removed in bringing the stock and scion into shape for grafting, carried with them a part of the woody zone of each internode, so that in cross-section the remaining part appears horseshoe shaped. In binding the scion to stock the tips of these woody rings were bound closely together (fig. 3), but in process of union parenchymatous tissue developed and intervened between the woody zones of the two members, resulting in their wide separation, as seen in figs. 2 and 4.

In sections of potato grafted to potato no new points were noted, the union occurring by the process described in the previous case, except that the brown wall which so strongly marks the junction in the case of the tomato was not nearly so prominent.

Potato and tomato graft.—The cross section of a wedge graft of a potato to a tomato, five weeks old, showed that similar tissues in stock and scion had met in the union. At the time of grafting numerous gaps and small spaces existed between the two members of the graft owing to the irregularities and unevenness of the cut. The parenchyma cells of stock and scion had elongated towards these places, being the direction of least pressure, and had filled up most such cavities, the line of meeting of stock and scion tissues being indicated by a wall twice the thickness of the ordinary cell wall. In other places this wall was very ragged and fragmentary due to dead cell walls which had been crowded into line by the growing tissues; shown in fig. 5.

The growth of the cells in closing up gaps is similar to growth of meristematic tissue induced by surface wounds. The cells just outside the path of the knife elongated in the direction of the severed surface to double the ordinary dimensions or more, then formed a series of transverse walls making what appeared in cross section to be series of narrow plate-like cells, the larger walls of which were parallel to the cut surface, the longer dimension being equal to the width of the cell from which they originated. (See figs. 5, 11, etc.) At the outer part of the section the central parenchyma of the stock was shown to

have met the cambium of the scion while the cambium of the stock met the parenchyma of the primary cortex in the scion. The union here was easily accomplished through development of meristematic tissue. The section showed the central parenchyma to have been more active in forming a union than was the primary cortex.

In one case where a potato scion had been grafted to tomato stock the central parenchyma of the tomato stock was bound against soft bast cells of the fibrovascular bundle. The bast cells had swollen as if attempting to enlarge, the cambium of the vicinity began an active growth, and a considerable quantity of meristematic tissue intervened between the central parenchyma and the bast cells of the fibrovascular bundle (fig. 6).

In one instance the knife in preparing the parts for grafting, had removed one side of a cell in the potato scion, while a cell of the stock had suffered a similar loss, and it happened that the free portions of the severed walls of these two cells were bound end to end. Through continued pressure the two partial cells had united, forming a cell twice the normal size, which lived and grew. This large cell, however, threw a delicate wall across its middle, forming two cells each of normal size, and providing such a neat union between stock and scion that it was almost impossible to detect it, the path of the knife showing no thickened wall, with but here and there a few fragments of dead walls projecting into the newly formed cell. See fig. 7.

The graft which presented the above interesting union also showed in an admirable way the action of parenchyma cells in closing up spaces existing, immediately after the operation, between members of the graft.

As previously stated the removal of pressure from one side of the cells both stimulates growth and induces elongation of the cells in the direction of least resistance. In this graft the cells had elongated towards the injured surface until their length was four times their width; delicate walls were then passed transversely across the cells dividing them into a series of small cells. These transverse walls appeared near the free end of the cell at first, and when any variation of size occurred in the smaller cells, as was often the case, the one most remote from the injured surface was the largest. Close examination revealed, in many instances, delicate young walls pass-

ing through the young cells at right angles to their longer axes. The free sides of these growing cells were much more thickened than the others (fig. 8).

The cross section of another graft of potato on tomato showed the central parenchyma of the tomato joined to the soft bast, cambium and fibrovascular bundles of the potato. Although the line of union was marked by a slightly thickened wall, no gaps were present and no development of meristematic tissue occurred. The junction of the two members was so neat as to be no more marked than the transition from one tissue to another in the same plant (fig. 9).

Geranium grafts.—Geraniums were grafted to each other with great ease. The action of these cells in effecting union, with occasional modifications, was similar to that seen in previous grafts of potatoes and tomatoes. Thickened brown walls generally marked the junction of the tissues, as in the former grafts; in some instances where gaps existed in this wall the cells of the stock and scion had so grown together as to wholly obliterate the path of the knife. In such places the longer axes of the cells were nearly at right angles to the line of junction (fig. 10).

Geranium and tomato grafts.—Geranium scions were easily united to tomato stocks, the geranium in nearly every instance thriving and increasing in foliage. The tomato scions would in no instance, however, accomplish union with a geranium stock. The repeated trials proved that in respect to grafting the two plants do not act reciprocally. As a partial explanation of this two facts are offered, viz: difference in the relative quantities of sap in tomato and geranium, and difference in acidity. The geranium has relatively much less sap than the tomato and in addition to this the sap is of greater acidity, so that in grafting osmotic action is set up between the tomato scion and geranium stock in which the tomato loses sap and at a time when it is least able to stand it and consequently perishes; in case of geranium scion and tomato stock the osmotic action would result beneficially to the scion supplying it with more sap at a time when it was in greatest need. Cross sections of these grafts showed the geranium to have been more active in the formation of the union (fig. 11).

Geranium and potato grafts.—Successful grafts were made with geranium scions to potato stocks. In this case as in the previous one the geranium was more active in forming the union,

as shown by the cells along the line of junction of the two members (fig. 11). In this graft the wall which marked the line of union was thickened but otherwise similar to ordinary cell walls.

Cactus grafts.—Cactus grafts were made, and sections showed the method of union to be essentially like that in the other cases studied. The union occurred in either one or the other of two ways: long continued pressure holding cell walls in contact gradually causing them to cohere, or through the development of meristematic tissue by each member.

Grafts of a monocotyledonous plant.—The only monocotyledonous plant experimented upon was *Tradescantia zebrina*, which was grafted to itself with great ease; and with much surprise it was also found to form a true union with a tomato stock. In grafting tradescantia to itself the members of the graft were firmly bound, and healing was rapidly accomplished. The examination of cross sections showed no general development of meristematic tissue so prominent in previously described grafts. Those parts of boundary cell walls which were on the line of union were very much thickened and from all appearances most of the union had been effected through long exerted pressure which caused the cell walls permanently to cohere. Where gaps or spaces had existed however elongation of cells in that vicinity had occurred as in other grafts. Where parenchyma met a fibrovascular bundle, and a space existed between the two, the parenchyma cells elongated towards the gap and divided, giving rise to new cells until the space was closed and the union accomplished through pressure of the cell walls as in previous cases.

Union of tradescantia and tomato.—In cross section of a graft of tradescantia upon tomato the union was found to be as perfect as any between tomato stock and potato scion. In many places tissues of both members gave evidence of marked activity in forming union, in others the outlying walls of border cells were thickened and union here was shown to have been the result of pressure of the border cell walls upon each other. The tomato was the more active in forming the union (fig. 12).

Examinations of callus.—Examinations of callus in tomato and potato slips, which had been placed in damp sand, were made in order to see what relation exists between the healing of these external wounds, and of the internal wounds of grafts.

The short account here given is from the examination of potato callus, as it showed all the parts clearly. From a longitudinal section it was seen that all the cells injured by the knife died, the parenchymatous tissues immediately beneath were vigorous and were stimulated to renewed growth. Elongation towards the cut surface occurred in the cells, and by forming successive transverse walls each elongated cell gave rise to several small cells, which rapidly increased in thickness of cell wall, and became rounded. These small cells pushed the dead cells in advance as they grew, and soon enveloped the entire injured tip and extended upward enveloping the sides of the branch with a mass several layers thick. The walls of the callus cells are thicker than those of the parenchyma cells, which give rise to them, and the cell contents are richer in protoplasm. The outer callus cells give rise to root hairs (fig. 13).

At the tip the transition from callus cells through meristematic tissue into ordinary central parenchyma is very gradual. The examination of the tip showed the first stages in the formation of callus to be similar to those in effecting union of tissues by grafting. Hansen, who has carefully studied the formation of callus, regards a cut made in a stem, when vegetative conditions are favorable, as a stimulus to extensive and complex activities. In the cut necessary to grafting we have the stimulus to growth, the parenchyma cells respond to the stimulus by developing meristematic tissue which in most cases effects the union.

More or less true callus may be found in the graft serving to protect injured parts which by reason of their position could never unite. If proper conditions of moisture be present the graft also frequently gives rise to rootlets as does the callus. The union of tissues in the graft and formation of callus is similar. Like causes produce each. One is the healing of an internal the other of an external wound. The callus may exist on the graft, and parenchyma which in one place produces a callosity to protect an exposed injury, in an adjacent locality effects a union between stock and scion, the process in each case being similar.

Summary.—We find that union in herbaceous grafting occurs in one of two ways: It is accomplished either by long exerted pressure holding old cell walls together and gradually causing them permanently to cohere, or through the develop-

ment of meristematic tissue by one or both members of the graft, after which the boundary walls meet and unite through pressure, somewhat as in the first case. We generally have part of the union in any particular case formed by the coherence of the walls of old cells, and the remainder formed by the growth of new cells arising, as in the case of callus, back of the cells injured by the knife.

Broken walls of the injured cells are thus pushed into line forming a brownish fragmentary wall marking the junction of the two parts of the graft. This wall tends to disappear with age; the smaller young cells along the junction of the two members enlarge rendering the line of demarkation between the two tissues faint.

In cases where the severed ends of two woody zones met, but were not sufficiently close to allow of union through coherence of cell walls, the two opposite ends of woody zones were enveloped by meristematic tissue arising from the cambium layer on the one side and the central parenchyma on the other. These two layers of meristematic tissue, meeting each other between the ends of the woody zones united as in the preceding cases, except no fragmentary wall separated them. When such a process occurred we had the woody zones of the two members of the graft separated by a layer of parenchymatous tissue similar in general form to a medullary ray. In cases where the woody cells met parenchyma cells for union they were often first enveloped by a growth of the neighboring parenchymatous tissue of the member of the graft to which they belonged.

It may be interesting to account for the transferrence of water from the stalk to the scion. The work of transferring water from one part of a plant to another is done largely by woody tissue, parenchyma being unable to do it. If parenchyma intervene between the woody tissues of stalk and scion throughout the graft the water supply of the scion is cut off. But this intervention did not occur throughout the graft where successful union was accomplished; while some sections did not show direct contact of the woody systems, others of the same graft always disclosed it. In dicotyledonous plants the binding of the graft nearly always brought the ends of the rigid woody rings in direct contact. In grafting of monocotyledonous to dicotyledonous plants, as in tradescantia and tomato graft the scattered woody bundles of the tradescantia

were often seen in direct contact with the woody cells of the tomato, thus giving opportunity for the transferrence of water from the one to the other.

Naturally one would not expect union between plants of different orders, and the successful grafting of *Tradescantia zebrina* upon tomato and of geranium upon tomato was a surprise. The union of tomato, a dicotyledonous plant, and tradescantia, a monocotyledonous plant, was particularly interesting and points to the fact that a similarity in the arrangement of the woody and other tissues is not essential in grafting herbaceous plants.

Opportunity is here taken to thank Dr. J. C. Arthur, of Purdue University, for his kind assistance in the preparation of this article, the work upon which it is based being done under his supervision.

Botanical Laboratory of Eli Lilly & Co., Indianapolis, Ind.

EXPLANATION OF PLATES XXX AND XXXI.

Abbreviations used: *l*, *l*, line of union; *G*, geranium; *T*, tomato; *P*, potato; *Td*, tradescantia.

PLATE XXX.—Fig 1, Long. sec. of *T* to *T*; *n* young cells formed in process of union.—Fig. 2. Trans. sec. of *T* to *T*; *w*, *w*, woody zone; *cp*, *cp*, central parenchyma: *cp'* cortical parenchyma; *m*, young cells.—Fig. 3. Trans. sec. *T* to *T*; *w*, *w*, woody zones; position of *w*, *w*, shown at time of grafting.—Fig. 4. Trans. sec. *T* to *T*, showing position of *w*, *w*, after graft had healed. —Fig. 5. Trans. sec. *P* to *T*, through central parenchyma; *n*, *c*, young cells. —Fig. 6. Trans. sec. *P* to *T*; *cm*, cambium tissue; *b*, bast cells —Fig. 7. Trans. sec. *P* to *T*, through central parenchyma; *n*, young cell walls; *a*, fragments of broken walls formerly occupying places of *n*.—Fig. 8. Trans. sec. *P* to *T*, showing growth of tissue and formation of young cells, *n*, *n*, in closing up gaps, *gp*, *gp*; *t*, *v*, young transverse walls dividing young cells; *t*, *t*, thickened walls of boundary cells.

PLATE XXXI.—Fig. 9. Trans. sec. *P* to *T*; *sb*, soft bast cells; *c m*, cambium layer.—Fig. 10. Trans. sec. *G* to *G*. *m m*, newly formed cells; *n n*, distorted parenchyma cells.—Fig. 11. Trans. sec. *G* to *P*; *n*, young cells. —Fig. 12. Trans. sec. *Td* to *T*; *f*, *b*, fibrovascular bundle; *n*, young cells. —Fig. 13 Long. sec. callus formation. *c*, *c*, *c*, on potato slip: *w*, fibrovascular bundle; *b*, bast cells; *c*, *p*, central parenchyma: *br*, the broken walls of cells injured in cutting the slip; *k*, formation of callus cells by parenchyma cells; *h*, trichome arising from callus cells.

Observations on the zoospores of Draparnaldia.

L. N. JOHNSON.

WITH PLATE XXXII.

Having been interested during the past season in studying various algæ I have been surprised at the lack of accurate descriptions of the zoospores and their mode of formation. Aside from the familiar papers on *Ulothrix zonata* little seems available, beyond scattered references in various text books.

The plant selected for special study was *Draparnaldia plumosa* Ag. Concerning this genus little information can be gleaned from the accessible books. The accounts by the older writers are chiefly interesting historically. For instance Decaisne[1] in 1842 spoke briefly of the zoospores, and figures them though with no attempt at detail. He says that he failed to see any motion of them either before or after their escape from the cell. It is possible that he saw only resting spores.

Kuetzing, in his "Metamorphose des vegetaux inferieurs,"[2] mentions finding Draparnaldia producing zoospores on one occasion, but lost the material before making any detailed study of them. He speaks with regret of thus failing to have the opportunity to investigate the vexed question whether zoospores were really animals. Before this Treviranus had observed the zoospores and shown that from them grew young plants of Draparnaldia.

Derbes and Solier, in a paper published in 1850,[3] gave a brief but concise account of the zoospores in the closely related *Stigeoclonium tenue* Kg.

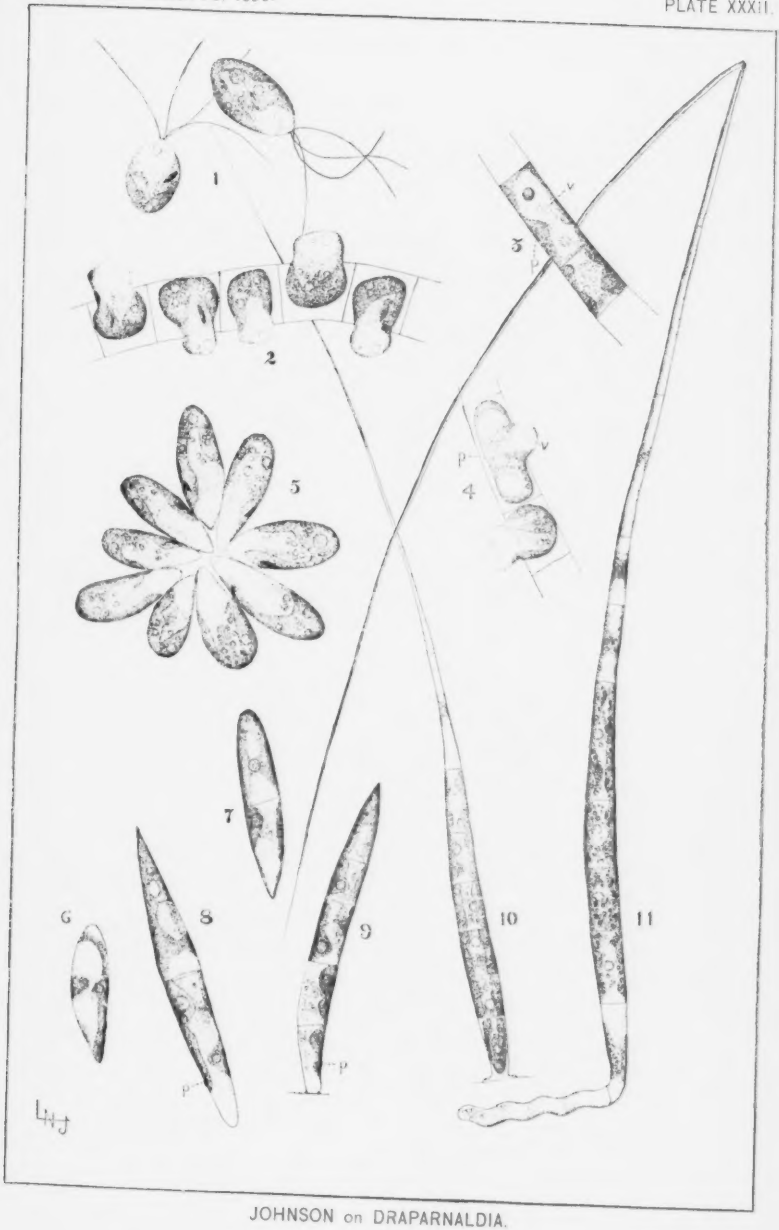
Aside from these references there is nothing available, at least to the average botanist. This being so it has been thought desirable to give a somewhat minute account of the structure and formation of the zoospores in the species mentioned.

The form of the plant is probably familiar to every botanist. The main axis is comparatively stout, and is made up of cylindrical or barrel shaped cells, with the walls lined by a

[1] Essai sur une classification des algues, etc. Annales des Sc. Nat. Bot. II. XVII. 314.

[2] Annales des Sc. Nat. Bot. II. XI. 136.

[3] Organes reproducteurs des algues. Ann. des Sc. Nat. Bot. III. XIV. 267.



JOHNSON on DRAPARNALDIA.

central transverse band of chlorophyll, containing several pyrenoids. On the sides of this axis and its main branches are borne numerous smaller branchlets, each itself branching copiously into a plumose tuft. The cells of these branchlets are shorter and their chlorophyll covers nearly the entire wall. Toward the end of the ultimate branchlets the cells are much longer, with the narrow chlorophyll band central. The young branchlet is tipped with a long hyaline multicellular seta.

The production of zoospores is confined to the branchlets, but to no particular part of them. Often the contents of all the cells of a branchlet become thus transformed, and it is not uncommon to find a vigorous plant changed in a single day to a naked axis surrounded by the empty cell walls of its branchlets.

The zoospore is ovate or oval in form (fig. 1) and averages about 12–16×8–10μ, though there is much variation in both form and size. The anterior end is rather pointed and nearly hyaline. On the tip are attached the four cilia, each rather longer than the body. The chlorophyll is parietal, but not uniformly distributed, and contains one or more pyrenoids. There is a bright red pigment spot, lanceolate in outline and apparently slightly raised above the surface. It is usually placed about on the middle of the side of the zoospore, in a diagonal position. It is always connected with the chromatophore, and in one case was observed at the very base of the body. At the anterior end of the zoospore there are two large contractile vacuoles, placed side by side and contracting alternately. Repeated observations showed that the average interval between two contractions of the same vacuole was about fifteen seconds. After contraction the vacuole often seemed invisible for about six seconds, then appeared and expanded gradually for ten to twelve seconds, when it suddenly and rapidly contracted. Occasionally the contraction was slower, occupying nearly a second.

Only a single zoospore is formed in each cell. The first sign of their production is apparently the formation of the pigment spot. This seems to be fully formed at least twenty-four hours before the escape of the mature zoospore, but the manner of its formation could not be determined. One can often find a branchlet differing apparently in no respect from those around it, except that each cell bears in some part of

its interior this bright red spot. This is especially striking when seen in one of the long terminal cells where the chromatophore lines but a small portion of the cell wall. In some cases the cells at this stage seem to have the contents slightly more granular than usual. The contents continue ordinarily to occupy the whole cavity of the cell wall up to the very instant of escape, though occasionally the zoospore assumes a somewhat rounded form while still within the mother cell. It is difficult to determine the exact time of formation of the vacuoles, but in every case where a vacuole was observed pulsating the zoospore escaped in less than fifteen minutes.

The escape of the zoospores takes place normally in the morning, and most abundantly from eight to ten o'clock, though not infrequently occurring at any hour of the day. Specimens collected in cold weather and brought into a warm room soon begin to discharge their zoospores in abundance, regardless of the time of day. They seem to be formed at all times of the year, having been observed by the writer in nearly every month.

There is usually no motion or change in the appearance of the zoospore to denote that the time of escape is at hand. Suddenly the wall gives way at one point, and through the opening bursts the zoospore, the hyaline end being invariably first to appear (fig. 2). The whole zoospore may escape almost instantly, or the process may be prolonged for at least a quarter of an hour. In a few cases the zoospore was seen with its anterior end protruding slightly from the small opening, and vigorously twisting, with a boring motion, apparently trying to force its way out. If the opening is not large enough for easy escape, the zoospore assumes a dumb-bell shape, the body gradually squeezing through. Figures 3 and 4 represent a specimen in which the escape was rather rapid. Just as the first drawing was finished there was a sudden bursting of all the cells, and every zoospore thrust its colorless end out. The other drawing (4), showing the same cells two minutes later, was hastily outlined, and in four minutes every cell was empty.

The zoospore is often held even after its body is free, by its cilia, which seem to get caught either inside the cell or by the mucilage covering it. Then follow violent struggles to get free. The opening in the cell wall seems to be produced, in part at least, by absorption of its substance, for no projecting edges can be seen.

As soon as the zoospore is free it darts rapidly away, with a rotary motion, and keeping the hyaline end forward. Under the microscope it never moves far in the same direction, but seems to turn at random. It is almost impossible to determine with any degree of accuracy the rate of their motion, but the result of repeated trials indicates an average velocity of about 6^{mm} per minute.

The period of activity does not seem to be very long—in no case observed longer than seven minutes. Judging from the distance to which they sometimes travel it must often be rather longer than this. At the end of the period the motion diminishes in velocity, and the body begins to rotate around the hyaline end. This motion soon grows slower, and after a few final quivers it ceases. In settling down the zoospores show a tendency to collect in groups like that shown in figure 5, or to attach themselves by their hyaline ends to bits of gravel, the larger filaments of the plant, or in fact any object which comes in their way. One often sees old plants completely covered by the masses of zoospores fastened to them. No signs of conjugation have been seen, but most of the zoospores germinate freely.

The contraction of the vacuoles ceases soon after the zoospore ceases its motion, and the cilia disappear. The cell quickly begins to elongate and a slight disc is formed on the hyaline end, by which it clings to the substratum. A cell wall forms around the hitherto naked mass, and the free end of the cell becomes pointed as it elongates. The elongation takes place above the pigment spot, leaving this near the point of attachment. The first cell division may take place in a few hours or may be delayed for several days. This divides the spore in such a way that the pigment spot always remains in the basal cell (fig. 7). It may persist till four or five cells have been formed (fig. 9), when it begins to grow fainter, and seems to be absorbed. About this time the basal cell begins to form an hyaline filament, which grows rapidly over the substratum, and serves as a hold-fast for the young plant.

By the time the filament has reached a length of ten or twelve cells the tip has elongated into a multicellular bristle, which growing rapidly soon becomes several times as long as the filament (figs. 10, 11). Of course the growth of the filament must then be intercalary. From this point the young

plant grows rapidly, and soon becomes large enough to begin the formation of another generation of zoospores, which it does almost before the main axis has been developed.

One of the most interesting and striking peculiarities of the zoopores is their behavior toward light. It has been said that they appear chiefly in the morning, but this is apparently due, in part at least, to the change of temperature, for it was proved by experiment that they were produced quite as abundantly in a perfectly dark box as in the bright light outside. The effect of the darkness seemed to be to slightly retard the time of formation, making its maximum about ten o'clock in the morning (in winter). The optimum temperature of the water seems to be about 17° C.

Like most other zoospores these are heliotropic, swarming toward the light in such numbers that the side of the vessel becomes coated with them. Various experiments were performed to determine whether this action was really due to the light or to the heat. The result of these experiments was to show that it is the light rays which influence them, though in some cases it seemed that the zoospores were slightly affected by the heat.

It may be well in closing to state that in autumn many plants were found whose filaments were transformed into chains of resting spores. These differed little in general appearance from zoospores, excepting that they lacked the pigment spot and vacuoles, and that their contents seemed uniformly distributed in a parietal layer. This was nearly homogeneous and contained several pyrenoids. They do not seem to leave the parent cells, but germinate, the shoot bursting through their wall. The appearance of these resting spores suggests that they are modified zoospores, but in none could any pigment spot be detected or any other proof of such an origin.

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EXPLANATION OF PLATE XXXII.

Figures 1–8 × 1150. Figures 9–11 × 850. All reduced one-third in engraving.

Fig. 1. Mature zoospores.—Fig. 2. Filament, showing zoospores in the act of escaping.—Figs. 3, 4. Two cells showing condition before and during escape of zoospores. *v*, vacuole. *p*, pigment spot.—Fig. 5. Cluster of zoospores, showing characteristic grouping as their motion ceases.—Figs. 6–11. Showing growth of young plant from zoospore.

New and noteworthy North American plants.

JOHN M. COULTER AND ELMON M. FISHER.

1. RANUNCULUS LAPPONICUS L.—The range of this arctic species is usually stated as "Lat. 50° and northward." Professor Macoun extends its range somewhat southward, in recording it from Prince Arthur's Landing, Thunder Bay. We now have it from the Lake Superior region of Minnesota, where it was collected by Mr. L. S. Cheney, of the University of Wisconsin, twenty miles northeast of Grand Marais. Mr. Cheney's specimens were collected in the same region as the imperfectly known *Anemone nudicaulis* Gray, which Dr. N. L. Britton has shown to be Ranunculus Lapponicus.

2. **Petalostemon glandulosus,** n. sp.—Glabrous and glandular throughout: stems herbaceous, striate, leafy, 2 to 6^{dm} high, from a somewhat woody base: leaves 2 to 4^{cm} long; leaflets six to twelve pairs, oblong or oblong-obovate, 5 to 6^{mm} long, obtuse or retuse, conspicuously black dotted beneath: spikes cylindrical, very dense, 4 to 9^{cm} long, on usually slender peduncles (5 to 8^{cm} long): bracts very narrow, long acuminate, much longer than the calyx: calyx rose-tinged, tipped with green, conspicuously glandular, 3 to 4^{mm} long, deeply lobed, with the very minute greenish teeth pubescent on the margins: petals white, linear, almost three times as long as the calyx; the vexillum broadly cordate: pod pubescent above.—Eastern Texas, at Hockley (*F. W. Thurow*, in 1890), and at Industry (*H. Wurzlow*, in 1892). Apparently nearest *P. candidus* Michx., in fact has probably been distributed as that species; but differs in being strongly punctate throughout, in the more numerous and short-oblong leaflets usually acutish spike, early deciduous bracts, and the prominently glandular strongly oblique calyx with much shorter teeth.

3. **Astragalus strigosus,** n. sp. — Whole plant grayish with coarse appressed pubescence, erect, 17 to 25^{cm} high, leafy, with many very slender stems from a somewhat woody base: stipules triangular, acuminate; leaves 7 to 11^{cm} long, with thirteen to twenty-one sessile acute narrowly linear to almost filiform leaflets (1 to 2^{cm} long): peduncles much shorter than the leaves, together with the elongated raceme (with ten to sixteen distant flowers) 10 to 15^{cm} long: flowers purplish, 1^{cm} long: calyx very strigose, the

subulate linear teeth about equalling the tube: pod linear, 18 to 20^{cm} long, about 3.5^{mm} broad, sessile. — Basin, Montana, July, 1892, *F. D. Kelsey.* One of the SCYTOCARPI, and nearest *A. flexuosus* Dougl., but distinguished by its many slender stems and leaves, linear and acute sessile leaflets, shorter peduncles with more elongated racemes, calyx with longer and linear teeth, wings with a short broad and acute appendage, and sessile pod.

4. **Astragalus atropubescens,** n. sp.—Stems and leaves grayish with appressed pubescence, becoming black hairy in the inflorescence and especially on the calyx: stems erect, 3.5 to 5^{dm} high, with very many slender stems from a woody base: stipules lanceolate, acute; leaves few, 13 to 20^{cm} long; leaflets twenty-one to thirty-three, linear-oblong, glabrate above, 15^{mm} long, cuspidate, very blunt (seldom retuse), short-petioled, usually with a cuneate base: peduncles much shorter than the leaves, together with the scarcely elongated (eleven to sixteen-flowered) raceme 12 to 20^{cm} long: flowers declined, ochroleucous, 1.5^{cm} long: calyx oblique, very black with appressed hairs, 5 to 6^{mm} long, the subulate teeth half as long as the tube: vexillum and wings much longer than the keel: pod linear-oblong, coriaceous, erect, stipitate (stipe 5^{mm} long), glabrous, straight, 2^{cm} long without the stipe, 5^{mm} broad, acute at base, acuminate at apex, deeply grooved on the back but not completely two-celled, the ventral suture scarcely acute.—Deer Lodge, Montana, June, 1892, *F. D. Kelsey.* The species seems to belong with the GALEGIFORMES but it has an erect pod and is not so leafy. In addition to the characters just mentioned it differs from *A. Drummondii* Dougl. in its appressed pubescence, much more black hairy calyx, and shorter linear-oblong pod; and from *A. scopulorum* Porter in its much more black hairy calyx, much shorter and acuminate straight pod with simple deep dorsal sulcus.

5. **Hedysarum flavescens,** n. sp.—Erect, 3 to 4^{dm} high, minutely pubescent: stipules connate, opposite the petiole; leaflets five or six pairs, oblong-elliptical, 1.5 to 2^{cm} long, slightly pubescent beneath: racemes fifteen to thirty-flowered, short, rather dense, elongated in fruit: flowers bright yellow, 15^{mm} long, the wings exceeding the vexillum, but shorter than the keel: calyx-teeth triangular-subulate, shorter than the tube: pod two or three-jointed, smooth.—Near Helena, Montana, May, 1892, *F. D. Kelsey.* Nearest *H. borealis*

Nutt., but distinguished from it by its more erect habit, fewer and usually broader (prominently cuspidate) leaflets, much shorter and denser racemes of larger bright yellow flowers, and wings larger than the vexillum.

6. RUBUS DELICIOSUS James. — Mrs. S. B. Walker, of Castle Rock, Douglas County, Colorado, has sent a form of this species with glandular pubescence on branches, young leaves, and calyx, but not so prominent as in *R. Nutkanus* Moçino. It was collected June, 1889, at an elevation of 7,000^{ft}. Mature fruit was not seen.

7. **Aster MacDougali,** n. sp.—Glandular throughout, minutely so below, densely so in the inflorescence and on the involucre: stems erect, 5 to 9^{dm} high, flexuous and corymbosely branched above or simple, soon becoming naked below, from a slender creeping rootstock: leaves oblong-ovate, acuminate, strictly sessile by a round or cordate base, thin, prominently nerved, coarsely and sharply dentate, scabrous on the margins, 8 to 13^{cm} long, 3 to 6^{cm} broad: heads few on each branch (13^{mm} high, 15 to 20^{mm} broad), terminating the densely glandular peduncles (2.5 to 4^{cm} long): involucre rather loosely imbricated in three or four series, the bracts narrowly lanceolate from a broad base, acute or acuminate, light-green with a glandular-ciliate and narrow scarious margin: rays twenty-five to thirty, pale blue, linear, 2^{cm} long: style appendages flat and broad (linear in the ray-flowers): stamens very acute: achenes linear-oblong, 6 to 10 nerved, villous, with simple very coarse densely bearded pappus.—Near Lake Pend d'Oreille, Idaho, August, 1892, at an elevation of about 3,000^{ft}, *D. T. MacDougal.* A very handsome species, near *A. acuminatus* Michx. in general appearance, but differs in being glandular pubescent throughout, in its sessile leaves with rounded or subcordate base, larger heads, more foliaceous lanceolate involucral bracts not so loosely imbricated, longer pale blue rays, flat and broader style-appendages, and much longer and villous (not glandular) achenes.

8. DODECATHEON CRENATUM Greene.—We refer here a Dodecatheon collected at Granite, Montana, July, 1892, at an altitude of 8,500^{ft} by *F. D. Kelsey.* The specimens are without fruit, and differ from the description of *D. crenatum* only in the leaves being entire or nearly so, and in the umbel being fewer-flowered. Mr. Kelsey says that the "flowers

when fresh appear coarse, large and showy." Possibly mature fruit will indicate greater differences.

9. MERTENSIA LANCEOLATA DC.—A low white-flowered form, with narrow sharply acute leaves, and filaments broader and longer than usual (almost twice as long as the short greenish anthers) has been collected by *Mrs. S. B. Walker* near Castle Rock, Douglas county, Colorado, 1892. The form would seem to deserve varietal rank in a less polymorphous species.

10. MIMULUS LEWISII Pursh, var. **exsertus,** n. var.—A tall form, with broader leaves (6 to 9^{cm} long, 2.5 to 3.2^{cm} wide) which are acuminate and perfectly entire, corolla 4.5^{cm} long with the broad tube about half exserted (limb reddish-purple and tube lighter colored), and the whole plant more or less viscid pubescent.—High mountains of northern Colorado, *George E. Osterhout* of New Windsor, Colorado.

11. **Pentstemon linearifolius,** n. sp.—Near *P. Lyalli* Gray, but grayish throughout with soft white pubescence: stems erect, about 3^{dm} high, from a very long horizontal slender woody rootstock: leaves smaller, linear (sometimes narrowly lanceolate), entire (rarely a very few indistinct serrulations), 4 to 5^{cm} long: raceme six to twelve-flowered, more glandular: flowers much smaller (2.5 to 3^{cm} long), light purple: anthers less woolly: pod oblong-ovate, very acute, 15^{mm} long, longer than the narrowly lanceolate attenuate sepals.—Near Lake Pend d'Oreille, Idaho, 1892, at an elevation of 3,000^{ft}, *D. T. MacDougal.*

12. PENSTEMON HUMILIS Nutt.—A form with longer peduncles and pedicels than usual, making a longer and laxer inflorescence, was collected by *Mrs. S. B. Walker* in Douglass County, Colorado, May, 1892, at an elevation of 7,500^{ft}.

13. PENTSTEMON CONFERTUS Dougl., var. CÆRULEO-PURPUREUS Gray.—A form with long peduncles bearing fewer flowers and so forming a much looser raceme, and with leaves almost uniformly denticulate, was collected near Helena, Montana, June, 1891, by *F. D. Kelsey.*

14. **Pentstemon ellipticus,** n. sp.—Erect stems herbaceous, minutely puberulent, 7.5 to 12.5^{cm} high, arising as branches from a more or less horizontal (apparently subterranean) woody stem: leaves firm but hardly coriaceous, broadly elliptical to nearly rotund, obtuse, 2 to 3^{cm} long,

1.5 to 1.8^{cm} broad, sessile, those on the sterile branches short-petioled and longer, distantly serrulate or entire, densely and minutely black-punctate beneath: the slender pedicels, leaf-like bracts, and sepals of the three or four-flowered racemes densely viscid pubescent: corolla violet-purple, 3.5^{cm} long, strongly bilabiate and ventricose, with narrow throat and erose lobes: sepals lanceolate, more or less attenuate, 10 to 12^{mm} long: stamens somewhat exserted, deep purple, with white comose anthers, the sterile one shorter and densely pubescent above: pod oblong-ovate, acute.—Near Lake Pend d'Oreille, Idaho, August, 1892, at an elevation of 3,000^{ft}, *D. T. MacDougal.* A member of the puzzling *P. Menziesii* group, which has been variously modified by Dr. Gray and Professor Greene. Our plant seems to bear some relationship in habit and general structure to the dwarf alpine *P. Davidsonii* Greene, but, of course, is very much larger in every way, the erect herbaceous leafy flowering branches rising 7.5 to 12.5^{cm} above the ground from a more or less procumbent or horizontal woody subterranean stem.

15. PLANTAGO PATAGONICA Jacq., var. **lanatifolia,** n. var. —Nearest to var. *gnaphalioides* Gray, but distinguished by its more spreading habit, floccose throughout with long silky white wool, more numerous (thirteen to twenty-one) oblanceolate broader (10 to 18^{mm}) usually five to seven-nerved somewhat minutely denticulate leaves, more numerous peduncles, thicker spikes (6 to 12^{mm} in diameter), and bracts but two-thirds the length of the sepals.—Texas, Hockley (*F. W. Thurow* in 1890), Industry (*H. Wurzlow* in 1891). This description includes two forms, one of which is very densely white floccose, with narrower and more numerous spikes and very acute leaves; the other more robust and spreading, with broader and scarcely acute leaves.

Herbarium Lake Forest University, Lake Forest, Ills.

Some recent investigations on the evaporation of water from plants.[1]

ALBERT F. WOODS.

At the meeting of the American Association for the Advancement of Science in August, 1891, a paper was read by Prof. Bessey and myself on "Transpiration; or, the loss of water from plants." In that paper we gave in a very condensed way the condition of this problem at that time.

We called particular attention to two papers by Dr. Alfred Burgerstein, published in 1887 and 1889, and called "Materials for a monograph relating to the phenomena of transpiration of plants."[2] Dr. Burgerstein's papers make a most valuable contribution to the literature of transpiration, and are invaluable to one who desires to make a critical study of the subject.

A pamphlet by Dr. Oscar Eberdt[3] is also a masterly presentation of the subject, and contains the record of many valuable experiments.

The investigations recently carried on by M. Henri Jumelle and published in the Revue générale de Botanique, have afforded us a clearer insight into the relation existing between evaporation and assimilation. M. Jumelle shows[4] that a ray of light, passing through the chlorophyll of a leaf, is partly used in assimilation and partly in chlorovaporization. If the supply of carbon dioxide is taken away from the plant, assimilation is, of course, stopped, and more of the energy of the absorbed light ray is left free to affect chlorovaporization.

In a series of experiments which I conducted on the internal temperature of plants, I found that a ray of light, after passing two parallel panes of clear glass three-fourths of an inch apart, filled between with a saturated solution of alum in distilled water, had a remarkable calorific effect on plant tissue rich in chlorophyll, quickly raising the internal temperature from 3° to 5°C. higher than the air. Direct light (that is,

[1] Read before the Botanical Seminar of the University of Nebraska, April 15, 1893.

[2] Materialien zu einer Monographie betreffend die Erscheinungen der Transpiration der Pflanzen. Verh. K. K. Zool.-Bot. Gesells. Wien.

[3] Die Transpiration der Pflanzen und ihre Abhängigkeit von äusseren Bedingungen. Marburg 1889.

[4] l. c. 1889, no. 1.

light not passed through glass or alum solution) had a much greater effect. In some cases, as in the petiole of the banana leaf in direct sunlight, the temperature was 20°C. higher than the air. The temperature decreases as the intensity of the light.

Green tissue warms much more rapidly than it cools. Living green tissue of cactus and castor-oil plant warms more rapidly than dead tissue of the same, but cools at about the same rate. The dead tissue follows very closely the temperature fluctuations of an equal bulk of water enclosed in a smoked glass cylinder. Checking evaporation causes a rise of temperature proportional to the decrease of evaporation.

The investigations that I made last year on the evolution of bubbles of gas by green plants, in water, exposed to light,[5] showed conclusively that this evolution of bubbles, from such plants as *Myriophyllum*, was not the result of assimilation, but the calorific effect of the absorbed light ray.

These few facts, taken from my reports presented to the Seminar last year, are certainly, as far as they go, confirmatory of M. Jumelle's results.

M. Jumelle's next work was on the influence of anæsthetics on the transpiration of plants. His apparatus was simple, consisting of a bell glass set in a dish of mercury. The openings through the top of the bell glass for the introduction of anæsthetic and carbon dioxide were under absolute control. The plant experimented with was placed under the bell glass and the water evaporated collected by calcium chloride. In the experiments on chlorophyllian transpiration in the presence and absence of carbon dioxide, the loss of weight of the plant was noted, as well as the gain in weight of the calcium chloride. But in the experiments with anæsthetics he considered that the loss of weight of the plant would not exactly represent the amount of water evaporated because of the weight of the ether absorbed by the anæsthetized leaves. In all cases M. Jumelle first determined the amount of anæsthetic necessary to stop assimilation without killing the plant. At the close of the experiment the plant was washed in water, after which, if the experiment had been successful, assimilation started again. The results of these investigations showed that in the light the effect of the anæsthetic was

[5] Extract published in Publication II of the Nebraska Academy of Sciences, 1892.

to increase transpiration. This Jumelle considered to be due to the fact that the anæsthetic, by affecting the chloroplast, stopped assimilation; thus more of the energy of the absorbed light ray was used in chlorovaporization. In the dark M. Jumelle found that the anæsthetized plant lost less water than the normal plant, but failed to come to any definite decision as to why this should be so.

MM. Verschaffelt[6] criticised M. Jumelle's methods of experimenting, and questioned his conclusions in regard to the relation of carbon dioxide to evaporation in the light and in the dark. They used in their investigations a modification of the Kohl transpiration apparatus. The modification consisted simply of a glass vessel containing culture fluid or water into which the roots, or in some cases the cut end, of the plant extended. The evaporation was measured by the loss of weight of the apparatus; of course no water could escape except through the plant. In the case of assimilating plants the water evaporated was collected by calcium chloride. This was because the Verschaffelt brothers considered that the increase in weight of the plant due to assimilation must be taken into account. They concluded that the transpiration of a plant in an atmosphere free from carbon dioxide is greater than in air containing it, both in the light and in the dark. Further, that the presence of carbon dioxide in the air decreases evaporation in the light independently of assimilation.

M. Jumelle made a critical discussion of the MM. Verschaffelt brothers' investigations and conclusions.[7] He went over his experiments with apparatus meeting all their objections and not only proved the correctness of his own former results but also showed where the MM. Verschaffelt made their mistake.

This article is followed by a final one[8] giving the results of further investigation of the points in controversy which results fully confirmed Jumelle's former conclusions, namely, that, in the light, the presence of carbonic acid gas in the air around the plant devoid of chlorophyll has no effect on transpiration. The influence of carbonic acid gas is exerted exclusively upon chlorophyllian transpiration.

The absence of carbonic acid gas from air supplied to green

[6]Bot. Centralb. XLII (1890). 373–374.
[7]Revue gén. de Bot. 1891. nos. 30 and 31.
[8]Revue gén. de Bot. Juillet 1891.

plants in light causes an increase in transpiration. This may be explained by the fact that the energy of the light rays absorbed by the chlorophyll, which energy is ordinarily partly used in assimilation, is here wholly free to effect transpiration.

In the BOTANICAL GAZETTE for February, 1893, is an article by Albert Schneider on the "Influence of anæsthetics on plant transpiration." In this article Mr. Schneider attempts to show how M. Jumelle came to erroneous conclusions. Quoting from Mr. Schneider's article: "Jumelle has lately been carrying on a controversy with Verschaffelt who maintains that ether increases transpiration in the dark as well as in the light. This Jumelle has attempted to disprove in his final paper on anæsthetized plants."

Mr. Schneider has evidently been a little careless in his reading or else has failed to indicate where he received his information. The only controversy, so far as I know, between M. Jumelle and MM. Verschaffelt has been on the relation of carbon dioxide to transpiration in the light and in the dark as before mentioned in this paper. M. Jumelle's final article (l. c.) has nothing in particular to say in regard to anæsthetized plants but deals wholly with the problem under discussion between himself and MM. Verschaffelt. Further Mr. Schneider says: "By way of criticism it must be pointed out that, in the first place, Jumelle as well as Verschaffelt used only portions of plants in their experiments and hence their conclusions are of little practical value." This criticism might be justly made had these investigators used, for the measure of evaporation, as did Mr. Schneider, the amount of water absorbed by the roots. When the loss of water is measured as they measured it, the results obtained from branches, properly prepared and supplied with water, are just as trustworthy as the results obtained from whole plants. M. Jumelle in his first reply to MM. Verschaffelt says distinctly that he used *entire* plants in order to exactly meet the conditions of the experiments performed by MM. Verschaffelt. Later however both investigators used branches as well as whole plants.

Turning now to Part III of Mr. Schneider's article, "Experiments on transpiration of entire plants"; first of all he has made a very great mistake in assuming that the amount of water absorbed by the roots of a plant represents the amount "transpired." By consulting Dr. Oscar Eberdt's inves-

tigations in the article mentioned in the first page of this paper it will be seen that this relation, even under the most favorable conditions is far too general and fluctuating to be of any value whatever as an exact measure of evaporation.[9] This difficulty alone is sufficient to make Mr. Schneider's results practically valueless as far as transpiration is concerned.

Further, M. Jumelle took special pains to ascertain the amount of anæsthetic that was required to stop assimilation *without killing the plant*, and always tested the plant after the experiment in order to be certain that it had not been killed. Mr. Schneider took no such precaution in his experiments, but says that he took "no special notice of the amount of anæsthetic used;" and further says that after a time the plants exposed were killed. He is thus dealing with plants under entirely different conditions from those maintained by M. Jumelle; hence, even had Mr. Schneider's measure of transpiration been reliable, his results could have no direct bearing on M. Jumelle's results or conclusions.

In part IV, "Experiments on transpiration of leaflets," Mr. Schneider estimates the transpiration by weighing the leaflets and noting the loss. The slight objection to this I have before mentioned and will let it pass. The second objection is that the leaflets were not supplied with water and the amount of anæsthetic supplied was too great to meet the conditions of Jumelle's experiments. The fact that the leaves were not supplied with water is alone sufficient to make the results at least extremely doubtful. It is unnecessary to discuss Mr. Schneider's article further at this time. It is certainly quite evident that his results do not affect M. Jumelle's conclusions.

Coming back now to the condition of the problem of "transpiration" as left by M. Jumelle. First, the presence or absence of the usual amount of carbon dioxide in the air has no effect on the transpiration of chlorophyll-less plants either in light or dark. Here certainly "transpiration" has no relation to assimilation. We know further that etiolated plants lose water much more rapidly in strong light than in the dark.

Plant.	*Darkness.*	*Diffused light.*	*Sunlight.*
[10]Zea Mais (etiolated). . . .	106	112	290^{mgr}
Zea Mais (green)	97	114	785^{mgr}

[9]See also Dr. Alfred Burgerstein's remarks on this subject page 67, part 2, of article referred to on first page of this paper. Also paragraph 748 on page 279 of Goodale's Phys. Bot.—Also Vines' Phys. Bot. page 99.

[10]Experiments by Wiesner, page 110, Vines' Phys. Bot.

Here again it is evident that "transpiration" is independent of assimilation. The greater loss from the green maize plant in light as compared with the etiolated one Wiesner refers to the fact that the rays of light absorbed by the chlorophyll of the green plant are converted into heat, a conversion which is not effected to the same extent by the etolin of the etiolated plant. If we now stop assimilation by any means the 785^{mgr} lost in the sunlight from the green Zea mais would, according to M. Jumelle, be increased, showing again that transpiration does not increase directly with assimilative activity in the protoplasm, but, on the other hand, decreases as assimilative activity increases. It is also known that as the vitality of the protoplasm decreases it loses its power of retaining water. We are justified, then, in maintaining that the excess of the loss of water in the light over the loss in the dark, both in green and etiolated plants, is due to the calorific effect of the light and is therefore purely a physical process, *evaporation.*

Now in regard to the relation of anæsthetics to "transpiration" in the dark. M. Jumelle's results show that the anæsthetized plant loses less water in the dark than the normal plant. This fact M. Jumelle says he can not satisfactorily explain. These results so far as I know have not been questioned but rather confirmed by other observers. I think, however, that all have made errors in conclusion on this point which I shall endeavor to correct. The influence of an anæsthetic on protoplasm in the dark is more marked than the influence of the same dose in the light. One would conclude from the data at hand that anæsthetized protoplasm has less power than normal protoplasm of resisting evaporation. We would expect the anæsthetized plant to lose more water in the dark than the normal plant.

In an investigation that I made, recently, on the relation of sulphuric ether to the opening and closing of stomata, I found that, even in moderately strong diffused light, a strong dose of ether nearly closed the stomata. In weak diffused light the action was very marked, especially so in the leaf of *Canna Indica* in which the stomata closed almost instantly when brought under the influence of ether. These experiments were repeated many times with essentially the same results. If, as these experiments indicate, the stomata of anæsthetized plants remain closed in the dark, we could readily understand why

the water-loss should be less. In order to avoid this difficulty (and another possible one, viz., the taking of water from the outer exposed cells of a plant in air containing ether, by the inner less exposed ones), I used moss plants (*Mnium sp.*) set in small metal pots. The leaves were large and composed of a single layer of thin walled cells. I first determined the maximum dose of ether that might be administered to a plant without causing death. The plants were put under the influence of ether, then removed to ordinary air, and the evaporation compared with that of normal plants. In strong diffused light and sunlight the leaves of the anæsthetized plant dried and curled rapidly while the normal plant was much more slowly and less affected. In weak diffused light the anæsthetized plants lost water most rapidly as shown by the drying and curling of the leaves while the normal plants were only slightly affected. In the dark the same results were obtained as in weak diffused light. The drying of the plant is most rapid if it is first put under the influence of ether, then removed to dry air containing only a small amount of ether. After the experiments the anæsthetized plants were washed in water and fully regained their former freshness, showing that the investigations had been made on living subjects.

The results of my experiments indicate that the effect of ether on the exposed plant cell, in the dark as well as in the light, is to decrease its power of retaining water and thus increase the supply for evaporation. In the dark as well as in the light evaporation increases as the activity or vitality of the protoplasm decreases. We have good reason to believe that "transpiration" would be nothing in a perfectly saturated atmosphere if it were possible to obtain such, and that it is nothing in all wholly aquatic plants. It is evident, therefore, that so-called "transpiration" is not something which protoplasm *does* but something which it *resists*. It is not a physiological function or activity of protoplasm although it may have a physiological relation to the normal development of certain plants or parts of plants. Transpiration is nothing more than *evaporation*.

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Noteworthy anatomical and physiological researches.

The plant and its relation to iron.

The recent investigations by Professor Molisch[1], given a "mention honorable" by the Paris Academy, is one of the landmarks in physiology. As, however, the student of vegetable physiology will read the paper, we shall give only the main results. The first part of the book deals with iron-reagents in general, and here the author gives a new reagent which he describes in these words: "Die meisten organischen Verbindungen, welche Eisen in maskirter Form[2] enthalten, lassen selbst in ganz ausserordentlich geringen Mengen ihr Eisen erkennen, wofern man die betreffenden Objecte ein oder mehrere Tage oder Wochen in gesättigter wässeriger Kalilauge liegen lässt und dann nach raschem Auswaschen in reinem Wasser den gewöhnlichen Eisenreactionen, am besten der Ferrocyankaliumprobe, unterwirft." This method was[3], however, on the suggestion of Arth. Meyer[4], afterwards revised and it was found that the potassium hydrate would contain minute quantities of iron which the globoids of the aleurone grains, or other parts of the cells, can take hold of and hoard. This was the case, even when the reagent was selected as "chemically pure." Therefore, this part of the book must be used cautiously. Having then traced the iron in a great many plants throughout the vegetable world, the author proceeds to show the distribution of the substance within the cell-organism, in the various organs.

Among the algae, iron was found in *Cladophora aegropila* Rabenhorst, the membrane of which is, to some extent, covered with a yellow or red layer of this substance, the cell-wall being also more or less impregnated therewith. In *Peyssonnelia squamaria* Dne., *Valonia utricularis* Ag., and in *Oedogonium*, an incrustation of similar appearance is also observed, while in *Mesocarpus*, *Spirogyra*, and certain diatoms, iron was found also in the cell-contents, penetrating the nucleus and the chlorophyl-band. Among the fungi, *Rhizomorpha fusca*, and among the lichens, the so-called "oxidized lichens" (*Lecidea declinans* Nyl., and other species) displayed a con-

[1] Die Pflanze in ihren Beziehungen zum Eisen. Jena. 1892. 3 Marks.
[2] I. e., in organic combination.
[3] Berichte der Deutschen Botanischen Gesellschaft. XI (1893) 73-75.
[4] Flora, 1892, Ergänzungsband p. 291.

siderable incrustation of iron. Among the mosses, *Fontinalis antipyretica* L. gave a very intense reaction, but only in the walls; the cell-contents never gave evidence of any amount of iron being present. In the procambium of the cotyledons of *Sinapis alba*, the author had a well marked reaction; during the first or second week of germination the iron disappears entirely.

Following this is a very important series of investigations on the "iron-bacteria:" *Crenothrix Kühniana* Rabenh.[5], *Crenothrix dichotoma* Cohn, and *Leptothrix ochracea* Kütz., previously studied by Cohn[6], Zopf[7], and Hugo de Vries[8] with regard to their iron-hoarding properties, and first noticed in this connection by Winogradsky;[9] Molisch finds that the iron even after its oxidation in the "Gallerthülle" of these algæ, never enters into their protoplasm. The outer slimy layer has a very singular attraction for the iron contained in the nutritive solution which there becomes oxidized. But the other parts of these plants have no specific oxidizing power.

By means of his reagent mentioned above, the author further showed that the chlorophyl-molecule contains *no* iron. Studies on chlorosis showed that deficiency of iron in the protoplasm of any plant which may be subject to chlorosis causes a general pathologic state of the plant, and that the condition named is only one feature thereof.

Fifty-five species of fungi gave iron-reaction. This, in connection with experiments in nutritive media, led to the result that at least for *Aspergillus niger* iron is indispensable, and that this substance seems to play a very important role in the life of many other fungi.—J. CHRISTIAN BAY.

Latent irritability.

Sachs[10], referring to his very extensive studies of root-geotropism, calls attention to a special side of root-life of tropical and other epiphytes, namely to the fact that certain root-hairs are not geotropic, but follow other laws in growing out

[5]=Cl. polyspora Cohn.
[6]Cohn's Beiträge I. 108.
[7]Entwicklungsgeschichtliche Untersuchung über *Crenothrix polyspora*. Berlin, 1879.
[8]Die Pflanzen und Thiere in den dunklen Räumen der Rotterdamer Wasserleitung. Jena, 1890.
[9]Ueber Eisenbacterien. Botanische Zeitung. 1888, p. 261.
[10]Physiologische Notizen. V. Ueber latente Reizbarkeiten. (Flora, LVII (1893). 1–15.

among the earth-particles. Experiments on the growth of the roots of *Solanum tuberosum* showed how the root-system of this plant, when the surroundings are arranged similar to those of an epiphytic vegetation develops in a way like that of a genuine epiphyte. The property of doing so is, as long as the roots live under ordinary circumstances, latent, the adaptation to surroundings giving rise to this new feature of root-life. The facts thus obtained are used by Sachs to explain saltatory biological variations, one of the features of the "struggle for existence." Those who explain each and every property in an organism by the proper selection of species forget that we had the properties, irritabilities, and energies of the organs *before* the selection, or, at least, we ought to search for them. What we understand as the original properties of the organized matter, is not told by anybody, but Sachs is sure, "that certain properties, irritabilities, etc., were originally present, on which the struggle for life, and the natural selection could exert its influence."

It is very interesting to see how Sachs, in the autumn of his life, holds up again experimental physiology before a school of biologists which too often makes deductions concerning general biological laws, adaptations, etc., from facts just as they find them and which does not trace these facts to their origin by means of experiment.—J. CHRISTIAN BAY.

Studies upon the Xylideæ.

How incomplete our present knowledge is of this family is only too manifest when we examine the literature upon this subject. It seems as if the majority of authors have restricted themselves to mere systematic treatises, as for instance Martius, Kunth, Seubert, Chapman, Grisebach and Ries, while anatomical studies are very few and scattered. The present paper[1] is, therefore, highly welcome, since the author gives us a number of details concerning the morphology and anatomy, besides describing and figuring several new and very interesting species.

The vegetative organs show morphological characters that are not only useful in the discrimination of species, but are also of great interest when considered from a comparative point of view. This is the case for instance with the ramifi-

[1] NILSSON, ALBERT: Studien über die Xylideen. Kgl. Svenska Vet. Akad. Hdlgr. XXIV. no. 14. pp. 75 pl. 6. Stockholm 1892.

cation of the axis. We have here three forms of shoots: (I) "vegetative-floral," where the leaf-bearing axis is terminated by the inflorescence; (II) "floral," the leaves of which are sheathing and bladeless; and (III) "vegetative," which bears leaves of normal shape, but where no inflorescence becomes developed, at least not in the first year.

The true "vegetative-floral" axis is the main stem itself, the "vegetative," on the contrary, representing a secondary axis. The "floral" shoot is also always secondary, and illustrates a biaxial ramification, such as is known from, for instance, a few species of *Carex*[2], and others of various families. The main-shoot is in these purely vegetative and develops continuously only leaves, from the axils of which the flowering stems become developed.

Most of the species of *Xyris* show the development of a "vegetative-floral" main-axis, while in others the main axis is merely "vegetative." *Xyris savannensis*, however, shows all three forms of shoots upon the same individual. The ramification becomes still more complicated, when two or even three shoots develop in the axil of each leaf; such shoots are either all "floral," or "floral" and "vegetative-floral."

The roots occur in the two forms "typical" and "mechanical," which are, mutually, very different in structure. The first of these show the same plan, with a few modifications which are characteristic of the respective species. Most interesting is the fact, already discovered by Van Tieghem[3], that the pericambium is interrupted by the protohadrome in certain species of *Xyris*. The "mechanical" roots, which were observed in *Abolboda brasiliensis* and some species of *Xyris*, have the central part composed of stereome, besides that the pericambium and the endodermis consist of very thick-walled cells.

The stem is mostly differentiated into an under-ground rhizome with sympodial ramification, and an above-ground, flower-bearing scape. *Xyris witsenioides* forms an exception by having a distinct stem above-ground, the length of

[2] WYDLER: Ueber die Axenzahl der Gewächse. Botan. Zeitung 1844. See also: CALLME: Ueber zweigliedrige Sprossfolge bei den Arten der Gattung *Carex*. Berichte d. deutsch. bot. Gesells. v. heft 5.

[3] Van Tieghem: Structure de la racine et disposition des radicelles dans les Centrolepidées, Eriocaulées, Joncées, Mayacées et Xyridées. Journal de Botanique I. 305.

which may reach 30^{cm}. The anatomy of the lower part of this stem was, however, like that of a rhizome. The scape varies in outline from terete to triangular, and shows frequently a conspicuous furrowing. The cells of the mechanical tissue differ from typical stereome-cells by their length and having their pores transverse. This has hitherto only been observed in the *Restiaceae*.[4]

The leaves show also several variations. They are, in regard to the arrangement of the tissues, centric, excepting in *Abolboda brasiliensis*, where they are dorsiventral.

The author discusses also the geographical distribution of the various species. While the genus *Abolboda* is restricted to South America, *Xyris* has been recorded from all parts of the world excepting Europe. One hundred and eleven species are enumerated of *Xyris*, and seven of *Abolboda*. Twenty-one are described as new to science.

Among the species of *Xyris* which are enumerated in this paper, several have been named and described by the same author in a previous note, entitled: "Ueber die Afrikanischen Arten der Gattung *Xyris*[5]", to which we hereby take the opportunity to call attention.—THEO. HOLM.

BRIEFER ARTICLES.

Notes from Gull Lake Biological Station of the University of Minn.—ROOTHAIRS IN ELODEA CANADENSIS.—In the absence of my anatomical library and periodicals I cannot say whether the presence of root-hairs in *Elodea* has been made out or not. De Bary in his *Comparative Anatomy* (Eng. tran. p. 55, 1884) seems to except *Elodea* from the root-hair forming plants, saying, "If we disregard the root-hairs which, with very vew exceptions (*Elodea*, Lemna, Ophioglosseæ) are universally distributed," etc.; and Van Tieghem in his Traité de Botanique, 1. 677, (1891), observes, "quelques plantes se montrent même dépourvues de poils radicaux, aussi bien si la racine est aquatique, comme dans l'elodée (*Elodea*)." While I do not yet know upon whose observation these statements are based, I can state that they must be corrected, for *Elodea Canadensis* growing in the outlet stream of Cullen lake, Cass

[4]MASTERS: Observations on the Morphology and Anatomy of the Genus *Restio*. Journ. Linn. Soc. VIII. (1865). Pl XIV, fig. 1.

[5]Öfversigt af Kgl. Svenska Vet. Akad. Förhdlgr. Stockholm 1891. no. 3. pp. 149–157.

county, Minnesota, shows in some specimens a very abundant formation of root-hairs. Copious material has been secured and a full description will follow later, if it turns out upon further examination of recent literature that such description is necessary.

SHORE FORMATION OF EQUISETUM LIMOSUM.—In the upper Cullen lake, the third of the series and at the head of the chain, a most luxuriant growth of *Equisetum limosum* has been noted. This plant takes the place of *Scirpus lacustris* over large areas and produces a characteristic shore and bar formation. In some places it is the only plant growing over areas many acres in extent. It reaches out into five or six feet of water and fringes the shore to a depth of four or five rods or even more. Much of the plant is var. *polystachyum* Brückner, while the type is rather more abundant. Nothing like this has previously been met with during a rather extended experience among the lakes of Minnesota. Commonly the plant, while abundant enough, does not produce a solid formation but is scattered amid sedges, rushes and limnetic grasses. At upper Cullen lake it covers territory doubtless a square mile or more in extent, to the total exclusion of any other archegoniate and of all metasperms. This gives a peculiar and highly archaic aspect to the shores and bars of the lake in question.—CONWAY MACMILLAN.

EDITORIAL.

THE ANNOUNCEMENT of an International Botanical Congress in America has drawn out some adverse criticism, and has excited considerable apprehension regarding the success of the movement. It is more than three years since the GAZETTE suggested that such a congress be held. There has been no material change in the conditions as understood at that time and as existing now. The feeling of uncertainty regarding the wisdom of calling for a congress is largely based upon the strong probability that comparatively few of the prominent European botanists will find it convenient to attend, owing to the distance. No one is in a better position to appreciate this, and the other difficulties connected with the project, than the members of the committee. Yet it has seemed best in the face of various obstacles to issue a call for the congress.

THE TERM "congress" calls up very different concepts in the minds of different persons. As to the distribution of the membership, if as claimed by Otto Kuntze the conclusions of the Genoa congress were invalidated because it consisted of sixty Italians and forty foreigners,

and was therefore degraded from an international to a local congress, the Madison gathering bids fair to result even more disastrously, for one correspondent declares that it is "likely to be less than national, even and altogether provincial-American." The Genoa congress has also been assailed as lacking authority to act, because its members were not truly representative; "*er hat sich also Gesetzgebung angemasst.*" The Madison Congress lays itself open to the same criticism. The opinion is also held that it is "outrageous to announce a program from which all original research is excluded," from which it may be inferred that any limitation of subjects whatever would find objectors.

THE SPACE at command does not permit a discussion of what an ideal congress might be, or even what the gathering at Madison might have been under other conditions and management; and all that can be attempted is to give a brief statement of what the Madison congress can reasonably be expected to accomplish under existing circumstances.

In the first place the Madison congress is at the close of a series of brilliant gatherings of American scientific societies extending over nearly two weeks. These societies are furnished with the necessary machinery for receiving, hearing and publishing papers, and will consider it an honor to accord visiting scientists from abroad the same privileges enjoyed by their own members. The visitor will find in these several audiences most appreciative and responsive listeners. By this fortunate circumstance the congress is enabled to exclude papers of research, as well as others which do not bear directly upon uniformity of usage, knowing that all interests will thus be even better subserved than could be done by any other method.

This arrangement also removes a most formidable difficulty as to time. The Genoa congress discussed but one small phase of the nomenclature question, less than was considered at the Rochester meeting, and heard but a few papers, and yet occupied a week. It would probably be impossible to keep the Madison congress together a week however interesting the program, following as it does such a long series of scientific gatherings. Yet it is desirable that the subjects considered should possess variety, as there are many botanists who "don't enjoy the prospect of being dosed with 'nomenclature'." To get variety with limited time and yet accomplish important results requires careful selection of topics.

THERE ARE QUESTIONS in various departments, many more than can be settled or even considered by a single congress, which demand attention from all those interested in the advancement of the respective

departments. In order that these questions may be suitable for the program of an international congress they should interest botanists, of whatever locality, or whatever language, and be genuinely debatable. Matters of fact do not call for discussion, but for investigation. Deductions, opinions, methods, usage and doctrines may be discussed. The class of questions most intimately affecting a large number of botanists, and which can be brought to a satisfactory solution easier and quicker by word of mouth than by pen are those relating to usage, and of these the nomenclature of classification is the most prominent, and should first receive attention.

To say that one is already tired of the seemingly interminable discussion of the nomenclature question is frivolous. It is a fundamentally important matter, and can only be settled by a better general understanding of the situation, and an authoritative agreement upon the chief points in debate. The sooner this is done the better for the whole science of botany, and of the allied fields of horticulture, etc. He who will not take hold of the work at hand because it is not the kind preferred, may be looked upon as a doubtful helper at any time.

BUT WHILE the so-called nomenclature question should be taken up by the congress, because most prominent and most urgent, there is no reason, and no disposition so far as we know, to exclude other questions suitable to the occasion. If any one has a topic in mind which he thinks appropriate for such a gathering, he should communicate it to some member of the committee. Whoever has nothing to offer, however, would do well to bear in mind that it is unqestionably bad taste for him who does not work to criticise him who does.

THE OPPONENTS of the congress are undoubtedly right in saying that a congress which does not uniformly represent the several botanical interests in various parts of the world, can not properly assume to exercise the full powers of legislation. But the questions upon which a well constituted congress are to pass can not be settled by a single discussion, and gatherings like that to be held at Madison, even if imperfectly representative, will greatly hasten a better general understanding and lead up to the final decision. It is a case of doing what one can and working toward the desired goal, rather than waiting idly for the ideal opportunity.

THERE IS STILL another reason why a congress should be held at this time. America needs to be botanically discovered by Europeans. The country has botanical wealth; a little crude, it may be, when compared with foreign riches, but still there is wealth, and it has yet barely come to the notice of most foreigners. What better time could there be, than when all the world is looking toward Chicago, to direct

the attention of the botanists of the world toward botanical activity in America? If the present congress does not prove all that its well wishers could desire, it may yet be the means of eventually securing upon American soil the truly representative international congress to which all will be willing to concede authority.

CURRENT LITERATURE.

A guide to wild flowers.

A short cut is always in order. Very frequently, however, one needs to be well posted in the geography of a country before a short cut is safe. It seems to us so with the book before us.[1]

Mrs. Dana endeavors to make a book which shall enable one to name plants which he is able to find without using "some key which positively bristles with technical terms and outlandish titles," and this because "their names alone serve as a clue to their entire histories." She has selected about 400 of the most conspicuous flowering plants of the northern United States, omitting the commonest and best known, as well as those with inconspicuous flowers, or those which are rare or introduced as escapes from gardens. Illustrations of very decided artistic excellence and accuracy are used freely. Ninety-seven of the 104 full page plates are original. Those species which are of the greatest beauty, interest, or frequency, have been selected for these drawings.

The plants are arranged in accordance with their colors and the season of blossoming. White, yellow, pink, red, blue and purple, and "miscellaneous" are the six main groups. It would seem however that some further subheads than these would have been exceedingly convenient. The descriptions of the plants with white blossoms cover nearly 100 pages, and one has to look over a considerable number of these in order to find any plant which he may have in hand. Nearly half of the white flowers enumerated belong to distinctively spring plants, and forty pages is rather a large area through which to look for the names. In our judgment the book would have been greatly improved had the author introduced some simple artificial keys which would have guided one in the path in which he is now left to grope.

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[1] DANA, MRS. WILLIAM STARR:—How to know the wild flowers: a guide to the names, haunts, and habits of our common wild flowers. Illustrated by Marion Satterlee. Third edition. 12mo. pp. xvi + 298. pl. 104. New York: Chas. Scribner's Sons. 1893.

The book will be for amateurs a useful supplement to Gray's Manual, but it is doubtful if they will reach certainty with this book so readily as with that. The difference in the number of technical terms which it is necessary to know in order to use the two books is not so great as appears at first sight.

A reader in botany.[1]

The second part of Miss Newell's Reader in Botany is as admirable in its selections and in the topics chosen as has been her other botanical work. The articles are taken from such authors as Darwin, Sprengel, Kerner von Marilaun, Wallace, Gray, Grant Allen, Lubbock, Halsted, and Mrs. Buckley. Several of the chapters are original with the author, and one on the common dandelion has been written for the reader by Mr. F. Le Roy Sargent. The topics chosen are well calculated to stimulate interest in the minds of young students, and they are all directed toward the interesting and attractive phases of plant life. Here are some of the subjects:—cross fertilization; protection of pollen; attractive and protective colors of fruits; weeds; how seeds travel; habits of insects in relation to flowers; epochs in the history of botany.

If such books were more often seen in high schools and students were taught thus to observe the habits of plants, we should hear less complaint from students that they never did like botany, and we should have less popular misconception of what botany really is.

Minor Notices.

Dr. B. L. Robinson has published his present views of certain caryophyllaceous groups[2], views that are of special interest as they have to do with the forthcoming part of the Synoptical Flora. The closely allied genera Silene, Lychnis, and Agrostemma are kept apart on the old lines. Silene is credited with fifty species, seven of which are introduced, and one is new, another being transferred from Lychnis. Several new varieties are made, S. Douglasii being especially favored. Lychnis also contains a new species. Otherwise, the author has given a very conservative presentation of a group in which there are several vexed questions as to generic delimitations. In this connection attention may be called to the suggestion of Mr. Frederic N. Williams[3] as to

[1] Newell, Jane H.:—A reader in botany. Part 2, Flower and fruit. Selected and adapted from well known authors. 12mo, pp. vi+179. figs. 36. Boston: Ginn & Co. 1893.

[2] Robinson, B. L.:—The North American Sileneæ and Polycarpeæ. Proc. Amer. Acad. xxviii. 124-155. [June 22, 1893.]

[3] Williams, Frederic N.:—The disintegration of Lychnis. Journal of Botany, xxxi. (1893). 167.

the rearrangement of generic lines. Taking the species represented by Silene, Lychnis, and Agrostemma, he finds that there are two primary subdivisions based on whether the capsule is truly unilocular or has remains of dissepiments at base. The latter will include most species of Silene, and exclude S. noctiflora and S. Virginica, for which (with some species of Lychnis) Röhling's genus Melandryum stands waiting. Further subdivisions are suggested, which are summarized in a table presenting no fewer than nine genera. This is surely at the other extreme from the view which would consider that all three allied species should be merged into one group. The nine genera suggested by Mr. Williams are Agrostemma, Lychnis (very much restricted), Coronaria (a Linnean genus revived to contain certain species usually referred to Lychnis), Petrocoptis (a genus founded by A. Braun to further circumscribe Lychnis), Heliosperma (a genus of Reichenbach founded for the same purpose), and Melandryum, all of which belong to the Lychnis-group of unilocular capsules. The proposed genera of the Silene-group are Vicaria of Röhling, Eudianthe of Reichenbach and Silene.

Dr. Roland Thaxter has just published a fourth contribution on the Laboulbeniaceæ[1]. These papers are but preliminary to an illustrated monograph of the group. The present paper is based upon material collected during the past year in Maine and Massachusetts and also from the collections of Coleoptera in the Museum of Comparative Zoology in Cambridge. The result is astonishing, for the known species are doubled and seven new genera are proposed, and this together with the great modifications in forms noticed, indicates the existence of a very large and varied group. In two of the new genera the sexes are found separated upon distinct individuals. The appendages peculiar to the group, and heretofore called "pseudoparaphyses," are now recognized as sexual and are designated as "antheridial appendages." Of the fifty-two new species described in this paper, twenty are referred to the genus Laboulbenia, five each to Acanthomyces and Ceratomyces, two each to Heimatomyces and Corethromyces, and one each to Cantharomyces and Peyritschiella; while the remaining forms are included under new genera as follows: Haplomyces, having three species; Rhadinomyces and Amorphomyces, each with two species; Dichomyces, Chætomyces, Idiomyces, and Dimorphomyces, each including a single species.

Miss Alice Eastwood has published a list[2] of plants growing

[1] Thaxter, Roland:—New species of Laboulbeniaceæ from various localities. Proc. Amer. Acad. xxviii. 156-188. [May 10, 1893.]

[2] Eastwood, Alice:—A popular flora of Denver, Colorado. Zoe Publishing Co. San Francisco. [No date.]

about Denver. It is meant to be something more than a list, for it contains more or less of popular description, but in the absence of analytical keys it can hardly aid the beginner in discovering the names of plants. It can be used as a useful check-list by the local botanist, and gives more or less information to the general botanist concerning the Denver flora.

DR. ALFRED C. STOKES has prepared a set of analytical keys[1] for the "fresh-water algæ and Desmidieæ of the United States." In his introduction he makes a strong plea for "analytical keys," claiming that the ability to readily discover the name of an object will often attract the beginner to further study. These keys, founded upon Rev. Francis Wolle's works, will probably enable amateurs to discover the names of the fresh-water algæ readily enough. There is no question that such handy keys of groups stimulate their study.

A HEAVY PAMPHLET from the division of vegetable pathology of the U. S. Department of Agriculture forms bulletin no. 4, and is devoted to the work of Dr. Erwin F. Smith upon peach yellows. This bulletin gives the experiments and conclusions of four years' work in testing the value of commercial and other fertilizers for the prevention and cure of yellows. In some parts of the country this method has been much relied upon, having been supported by very good scientific authority. The extended and careful labors of Dr. Smith, however, show it to be worthless. The experiments upon which this conclusion is based have been very thorough and form an admirable continuation of Dr. Smith's previous researches upon yellows.

DR. L. M. UNDERWOOD has published in the Memoirs of the Torrey Botanical Club an index of the literature of the Hepaticæ. The purpose of this index is "to present an author catalogue of the publications relating to this group, supplemented by a topical index for the purpose of more ready reference." It is to be completed by "an index of all species described, with references to each of the genera recognized at the present time, and a classified arrangement of the species to show our present knowledge of their geographic distribution." It is needless to say that the work will be exceedingly useful to all students of the Hepaticæ. The present part forms the first ninety-one pages of the fourth volume of the Memoirs.

THE REPORT of the Division of Vegetable Pathology of the U. S. Dep't of Agriculture for 1892, by the chief, Mr. B. T. Galloway, deals

[1] STOKES, DR. ALFRED C.:—Analytical Keys to the genera and species of the fresh water algæ and the Desmidieæ of the United States. pp. 117. One plate. Edward F. Bigelow, Publisher. Portland, Conn. 1893.

with the work which has been carried on during the year upon grain rust, leaf blight of pear and cherry, black rot of the grape, gunshot disease and rust of almond and prune, peach yellows and rosette, pear blight, and other diseases of cultivated plants. The results are of great economic value. Attention is called to the urgent necessity of giving more attention to questions of physiology in connection with pathological investigations.

AN AID TO THE STUDY of the plants of Queensland has been issued from the government press at Brisbane, for free distribution, prepared by F. M. Bailey, F. L. S., colonial botanist.[1] It embraces some account of the morphology and physiology of flowering plants, an extended glossary of botanical terms, and the characters of seven of the most important orders of Australian plants, i. e., Leguminosæ, Myrtaceæ, Rubiaceæ, Compositæ, Proteaceæ, Euphorbiaceæ, and Gramineæ, together with the characters of all the tribes and of one genus and species under each order.

PART SEVEN of the first volume of Contributions from the National Herbarium is devoted to a systematic and alphabetic index to new species of North American phanerogams and pteridophytes published in 1892. It is compiled by Miss Josephine A. Clark of the Herbarium Library. It is accompanied by a supplement to the index for 1891 covering several pages, including chiefly some plants from Costa Rica, which were overlooked in the publication of the preceding year.

AN INTERESTING pamphlet of thirty-seven pages, by Dr. W. J. Beal, has recently been distributed. It contains (1) the report of Dr. Beal as professor of botany in the Michigan Agricultural College, for the year ending June 30, 1892, (2) a chronological history of the botanical department of the college, and (3) a full report of the exercises at the laying of the corner stone of the new botanical laboratory.

THE ELEVENTH part of Husnot's Muscologia Gallica has just been issued. It deals with several of the genera which have been heretofore in this country reckoned as sub-genera of Hypnum. Ten plates accompany the part. The work evidently draws near its close, and maintains its high standard.

A REPORT ON THE SISAL HEMP of Florida, and other fiber-producing agaves, has been prepared by Chas. R. Dodge, of the U. S. Department of Agriculture. It is well illustrated and contains much interesting information.

[1] BAILEY, F. M.:—A companion for the Queensland student of plant life. pp. 108. 8vo. Brisbane, Government Printer; 1893.

[2] DODGE, C. R.:—A report on the leaf fibers of the United States. Rep. no. 5 on Fiber Investigations. Dept. of Agriculture. pp. 73. 8vo. 10 plates and 12 figs. in text. Washington; Gov't. Printing Office. 1893.

OPEN LETTERS.

A suggestion.

Although the "Botanical Society of America" is still only a society "*in spe*", our confrére Dr. Britton has already (June number of the Torrey *Bulletin*) suggested a publication which he thinks the society might issue.

We earnestly hope that the day is not far distant when this society, to which Prof. Bailey gave the first impulse, will be started. The suggestion of Dr. Britton is that its journal be similar to Just's *Botanische Jahresberichte*, with this difference, that it should notice only papers printed in United States.

Is it really true that an American "Just" would be the ideal one? Would it be one most beneficial to botanical study in this country?

We cannot agree with Dr. Britton in this matter and for the following reason. Every botanist who really desires to keep himself "á jour" with our publications has so many opportunities to get the papers themselves, that a reviewing journal seems rather superfluous. The botanical papers of this country appear as a rule in some report, proceedings or in periodicals that are always easily accessible in almost every city. (The index in the Torrey *Bulletin*, however, is always welcome as a guide to what has appeared, and we hope Dr. Britton will not bring this part of the *Bulletin* to a close. The index might be printed in smaller type so as to save space, or the editors might publish it as an appendix to the *Bulletin*.)

It is true, that Just's *Jahresberichte* do not give many reviews of American literature, but this is our own fault. If the American botanists would always send copies of their papers to the editor of the *Jahresberichte*, as well as to all the leading botanical journals in Europe, in which reviews are given, they would then have the satisfaction of seeing their papers reviewed or at least referred to.

If, however, we have something like the *Jahresberichte* in this country, but confined to American literature, what would be gained? A certain class of botanists would content themselves with reading these reviews and would never look at the paper itself. We venture, therefore, to suggest a publication of an entirely different character.

The society should publish a monthly journal containing papers of a strictly scientific character, but which are too long to appear in any of the older journals. When we say "strictly scientific" we mean original researches, based upon thoroughly scientific investigations. Not "a list of plants collected here or there" or "new species of so and so" or purely systematic monographs, but solid contributions to botanical knowledge in the broadest sense, papers on geographical distribution, sketches of vegetation, studies of morphology, anatomy and physiology. These papers should appear in good form, having been first examined and approved by a board of editors, for in this way both writers and readers would be saved from seeing bad blunders and misstatements. This last feature is what we need most of all, to have our manuscripts examined and criticized before the printer puts them into immortality. We believe we would get much more satisfaction out of our work, and we certainly would have to strive a good

deal more than some of us are doing now. Still another thing would be gained. We would have uniformity in our botanical writings, in terminology for instance. This is a matter that is needed badly now, when the Century Dictionary and Crozier's Dictionary of botanical terms have done what they could to spread the worst kind of botany abroad.

The society will have much to do, but we believe there are enough to help, and when once started, it will check the existing evil C'est le premier pas qui conte.—THEO. HOLM, *Washington, D. C.*

[Mr. Holm would do well to broaden his ideas of "strictly scientific" botany.—EDS.]

NOTES AND NEWS.

BROWN UNIVERSITY bestowed upon Prof. W. W. Bailey the honorary degree of A. M. at the last commencement.

PROF. DR. L. WITTMACK of Berlin, editor of *Gartenflora* and member of the German Botanical Society, will attend the Congress in Madison.

HENRI DE VILMORIN has been appointed to represent the Société Botanique de France at the International Botanical Congress at Madison this month.

THE THIRD EDITION of *Les Maladies de la Vigne* has brought its author, Pierre Viala, well known in America, the Desmazières prize of the French Institute.

COUNT UGOLINO MARTELLI, of Florence, secretary of the Italian Botanical Society, and Prof. Luigi Macchiati of the Royal University of Modena, will be in attendance at the Madison Congress.

CATALPA SPECIOSA has just flowered for the first time in Europe, at Baden Baden, according to Mr. Max Leichtlin in *Gardener's Chronicle*. The trees were sent in 1879 by Professor C. S. Sargent.

ZOE is rapidly increasing the annotations upon our card catalogue of species, each number containing much material of all kinds. We note the name of Professor Douglas H. Campbell among the editors.

IN HIS handbook of the Pteridophytes of South Africa, just published, Mr. T. R. Sim includes 179 species, forty-two of which are peculiar to the cape. All Pteridophytes known to occur south of the tropic of Capricorn are included.

AN INTRODUCTION TO SYSTEMATIC BOTANY, by Prof. Charles E. Bessey, of the University of Nebraska is announced from the press of Henry Holt & Co. The author proposes to make the work correspond to its title. It is intended for beginners, and the students will be introduced to plants of all the groups.

THE REV. Arthur C. Waghorne, of Newfoundland, has for sale sets of Labrador Sphagna (25) for $2.00, and sets of Newfoundland and

Labrador Sphagna (44) for $4.00, named chiefly by Drs. Warnstorf and Eaton. Apply, during his absence on the Labrador, to Mr. A. T. Waghorne, City Engineer's Office S. Whies, Newfoundland.

MR. THOMAS MEEHAN has been honored by the presentation of a large and beautiful silver placque encased in carved mahogany and plate glass from the citizens of Philadelphia in recognition of his successful efforts in securing the establishment of small parks in various parts of their city. The gift is an elaborate design of high artistic merit.

A REVIEW of recent investigations upon carbohydrates written by Prof. W. E. STONE, appeared in the July number of "Agricultural Science," pages 177–186. It gives a good insight into the new and numerous investigations carried out by Tollens and his staff, as well as by others who are working under the influence of Tollens' new teachings in this particular field.—BAY.

IN A SERIES of about forty experiments carried out by W. Detmer (Ber. d. deutsch bot. Ges., XI. 139) it was found that plant organs without chlorophyll, (e. g., petals, roots, mycelium) exhaled the same amount of carbon dioxide in darkness as in light, whether direct or indirect, the temperature being kept the same. Furthermore no daily periodicity could be detected.

AN ERROR sometimes made in the formation of specific names is pointed out by Saint-Lager[1]. When the specific name takes the form of a Latin adjective, compounded from a noun and an adjective, the stem word should be united to the adjective with an *i*, although the noun may belong to the first declension. Thus, rutæfolius, tiliæfolius, calendulæflorus, tunæformis, etc., are incorrect and should be written *rutifolius*, *tiliifolius*, *calenduliflorus*, *tuniformis*, etc.

FROM RECENT REPORTS of the office of Experiment Stations we learn that there are fifty-four agricultural experiment stations in the United States, of which thirty-one employ botanists. Twenty-two stations have each one botanist, and nine have two, one of these being an assistant in most cases. This makes a total of forty persons connected with the stations who are engaged in botanical research. Of this number ten are also working in entomology, three in horticulture, one in aboriculture and one in meteorology.

A TRANSLATION of Zimmermann's work on the methods in microscopical botany by Dr. James E. Humphrey is announced for August. The work will be a very acceptable addition to manuals for the laboratory. It covers in about 300 pages the various operations of preparing various kinds of materials for the microscope, including microtome work, and the detection of organic and inorganic substances by micro-chemical methods, together with methods for bacteria. The work will be illustrated.

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[1] Un chapitre de grammaire à l'usage des botanistes. Paris, Baillière et fils, 1892.

"A NATURAL system of the action of poisons" is the title of a new book published by Dr. O. Loew in Munich. The author regards these actions with special refernece to the protoplasm, and its constituents. The book contains a rich amount of new and important facts which bear directly upon physiological and biological questions (living albumen, immunity, etc.) Complying with the author's wish, we shall give a review somewhere else; but it ought to be said here that Loew's book must receive attention from all students of physiology.—BAY.

THE BULLETINS from the experiment stations, which have come to hand since the last notice, include two (Va., no. 20 and S. D., no. 35) upon specific plant diseases and their remedies, one by T. A. Williams, (S. D., no. 33) on some plants injurious to stock (loco weeds and ergot), one by Geo. F. Atkinson (Cornell, no. 53) on œdema of the tomato, a very interesting non-parasitic disease, and one (Ohio, Tech. ser., I, 3) containing a number of articles relating to the state flora, including a full bibliography, by W. A. Kellerman, Aug. D. Selby, Wm. C. Werner, and Freda Detmers.

WEHME[1] cultivated a new fungus of which he describes two species namely *Citromyces Pfefferianus*, and *C. glaber*. It belongs to the group of moulds still imperfectly known that breaks up sugar and forms, besides other products, an organic acid. The new forms here mentioned may be caught from the air, and develop in solutions of sugar and other nutritive matter. It transforms half or more of the dextrose into citric acid, and can be used for the manufacturing of the latter. The two species named here will be more fully described later. Their maximum of growth lies below that of their fermentative power. They seem to be facultative anaërobionts. Anorganic acids, even in small proportions, and CO_2 have a deleterious effect as well upon growth as upon fermenting power.—BAY.

ZACHARIAS PRESENTS a paper in the Ber. d. deutsch. bot. Gesells. XI. 293, on the chemical constitution of the protoplasm. So far as has been ascertained certainly the cell protoplasm and the cell nucleus consist for a greater portion of their mass of substances which are insoluble in artificial gastric juice. To these substances belong the greater part of the material of the chromatin bodies of the nucleus. The other insoluble substances, heretofore passing generally under the name of plastin, show even after digestion a different reaction from those of the nucleus. Both protoplasm and the nucleus contain also proteids soluble in digestive fluid. The nucleolus is particularly rich in these, whereas the cell protoplasm, especially in full grown plant cells, seems to be poor in soluble proteid. Globulin and albumin, both of which are widely distributed in plant as in animal cells, do not seem to form a considerable part of protoplasm. The latter appears to be made up in the main of far more complex proteid substances.

[1] Ueber Citronensäure-Gährung. (Sep. from Sitzungsber. d. kgl. preuss. Akad. d. Wiss. zu Berlin. XXIX. pp. 519–523, 1893.)

BELAJEFF'S earlier researches on the germination of the pollen grain in the conifers and the homologies of its organs have been referred to in this place. More recent researches support his earlier ones and his conclusions on the homologies are interesting. He finds that the pollen tubes of the Abietineæ have the most complex structure, because at the base of the tube there are two small fixed cells which he considers the vegetative cells of the prothallium. The large cell which forms the tube is homologous with the antheridium of the cryptogams. This antheridium consists of a large outer cell, which extends to form the tube and answers to the wall-cells, and of an inner cell which is the equivalent of the mother cell of the spermatogenous complex. This mother cell divides into three cells, of which the two anterior function in fertilization while the third is disorganized. In the Cupressineæ, however, the structure of the pollen tube is much simpler, since there are no fixed cells, the entire prothallium being reduced to an antheridium which is like that of the Abietineæ. In Taxus a further simplification occurs in that the mother cell in the antheridium divides into only two cells of which one is functionless. The parts in the angiosperms are essentially as in Taxus.—Cf. *Ber. d. deutsch. bot. Gesells.* XI (1893). 198.

THE OCCURRENCE and physiological significance of myrosin in plants has been the subject of a research by Wilhelm Spatzier. His results are published in Pringsheim's *Jahrbücher*, XXV. (1893). 39, and may be thus summarized. Myrosin occurs in the Cruciferæ, Rosedaceæ, Violaceæ, and Tropaeolaceæ; in the first two in the seeds and vegetative organs, in the last two only in the seeds. In the seeds and vegetative organs of the Cruciferæ and in the seeds of the Tropaeolaceæ it is found in special cells, the myrosin tubes. In the aerial vegetative parts of the Resedaceæ it is contained exclusively in the guard cells of the stomata; the roots contain no myrosin. In the seeds of Viola and Reseda no myrosin tubes could be discovered. In the myrosin tubes of the vegetative organs the myrosin exists in a dissolved state, whereas in seeds which are poorer in water, it is always in solid homogeneous granules, without inclusions, about the size of the aleurone grains. It is a product of the protoplasm. Its formation is independent of light and continues as long as the formation of new organic material goes on. From the parts of a plant which are becoming functionless it is sometimes not, sometimes partially, but never wholly, resorbed; so that it seems to be intermediate between secretions in the strict sense and reserve material. Myrosin doubtless serves to form glucosides, of which however we know but two, potassic myronate and sinalbin, the latter being the so-called "mustard oil." What other glucosides it may form and what their rôle in the plant economy may be is unknown.

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